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धान की पार्बोइलिंग — रीति संहिता

(पहला पुनरीक्षण)

Paddy Parboiling — Code of Practice

(First Revision)

ICS 67.020

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FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Agriculture and Food Processing Equipment Sectional Committee had been approved by the Food and Agriculture Division Council.

Chemical analysis of rice shows that most of the nutrients which are concentrated in the outer layers of the rice kernels are lost during milling. Studies have shown that in order to reduce the loss of nutrients during milling and to minimize the breakage of rice, the paddy should be cleaned and treated (soaked, steamed and dried) before milling. This pre milling treatment of paddy is known as parboiling. Therefore, a need was felt to prepare this standard to streamline these processes and incorporate various methods of parboiling including traditional methods as well as modern methods of parboiling.

This standard was originally published in 1987. In this revision, the standard has been brought out in the latest style and format of the Indian Standards. Further Amendment No. 1 has also been incorporated.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 2022 ‘Rules for rounding off numerical values (*second revision*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

PADDY PARBOILING — CODE OF PRACTICE

(First Revision)

1 SCOPE

This standard covers conventional and various improved practices for paddy parboiling.

2 PARBOILING PROCESS

2.1 Parboiling of paddy is a hydrothermal process that may be defined as the gelatinization of starch within the rice grain. During the process, an irreversible swelling and fusion of starch granules occurs that changes the starch from a crystalline form to an amorphous one. As a result of this transformation, the orderly polyhedral structure of the compound starch/granules changes into a coherent mass.

2.2 Parboiling of paddy requires three steps, namely, soaking, steaming and drying.

2.2.1 *Soaking*

Paddy, being a hygroscopic material, can absorb water both as vapor and as liquid and thereby swells. The process of simultaneous absorption of water and swelling is known as soaking, steeping or imbibition. Generally, the moisture content of soaked paddy is about 30 percent to 35 percent on wet basis (w.b.). The soaking is basically a diffusion process. The movement of water into the paddy will continue as long as the vapor pressure inside the grain is less than that of the soaking water and will stop when equilibrium is reached.

2.2.1.1 For soaking to be effective, following conditions appear to be necessary:

a) Grain size should be uniform. This determines the depth to which the water penetrates;
b) The caryopsis should be entirely covered by the husk. If the caryopsis is exposed, its shape and colour would be spoilt;
c) A certain affinity must exist between absorbent and absorbate;
d) A diffusion pressure gradient must exist between the water vapor of the absorbent and that of the material to be imbibed; and
e) Temperature of water for soaking is to be maintained at 70 °C by circulation of hot water/steam.

2.2.1.2 The diffusion pressure of dry paddy is practically zero, therefore, when it is immersed in water, a steep diffusion pressure gradient is established and water moves rapidly into the grain.

2.2.1.3 Soaking is the result of different process, such as molecular absorption, capillary absorption and hydration. During soaking of paddy, water molecules first adhere to the surface of the husk and penetrates through the micropores of the husk into the rice kernel where they may be retained in voids or intergranular spaces due to capillary absorption. Some of the water molecules will be absorbed in starch granules, whereas others will enter into the lattice of the starch molecules where they will be held as water of hydration.

2.2.1.4 The water is drained at the end of soaking process.

2.2.2 *Steaming*

The use of steam for gelatinizing the starch is preferred to other methods of heating as it does not remove moisture from the soaked paddy, rather it adds moisture by condensation, which increases the total moisture content of grain. The moisture content of paddy increases to about 36 percent to 40 percent (w.b.) during steaming. The other advantages of steaming are:

a) It has a high heat content which is applied at constant temperature;
b) It is clean and sterile, without smell or taste;
c) It can be used first to produce power before it heats the paddy; and
d) It can easily be controlled.

2.2.2.1 During steaming, the following points should be considered:

a) Whether the steam is saturated or super-heated;
b) The pressure of the steam which determines the temperature at which heat is transmitted; and
c) The suitable steaming time which determines the total heat applied to the different varieties of paddy to cause the gelatinization of the starch.

2.2.2.2 The total amount of heat applied to the paddy is equal to the heat provided by the soaking water and the heat derived from the condensation of steam during the steaming operation.

2.2.2.3 The temperature of the steam has a considerable effect on the colour of the rice although the causes are not yet fully understood. Apart from the spread of the colouring pigments contained in the husk and bran, it seems that colouring of the endosperm is caused by absorption of reducing sugars that react with the amino acids, and by fusion of the aleurone layers of the endosperm with the starchy core. However, by steaming the paddy with non-pressurized steam (at 100 °C) as in traditional methods, only small variations are found in the colour and quantity of soluble starch and in the amount of swelling of the milled parboiled rice.

2.2.3 *Drying*

Drying of steamed paddy is essential for proper milling and storing but it is different from drying raw paddy as the steamed paddy has a high moisture content (36 percent to 40 percent w.b.). The main aim of drying process is to reduce the moisture content to 13 percent to 14 percent without causing cracks or stresses in rice caryopsis which may lead to breakage during milling. Tempering of paddy in tempering bin for about 8 hours is done to equalize mixture.

2.2.3.1 The manner in which excess moisture is removed is of considerable importance. If the moisture is removed at a very slow rate, micro-organisms will grow and spoil the parboiled paddy partially or fully. On the other hand, if drying is done rapidly and continuously, cracks may develop due to internal stresses and the rice will break during milling. However, if parboiled paddy is uniformly dried by any means (shade, sun or hot air drying), practically no breakage will occur. Improper drying conditions may result in very high breakage. It is advisable to dry parboiled paddy slowly.

2.2.3.2 During drying, two points are of great importance. First breakage does not occur throughout the drying process. It occurs when the moisture content drops to 18 percent and below. After that breakage increases sharply. Second, the cracks do not develop during drying but over a period of two hours after the drying has been terminated. Drying of parboiled paddy should be done in 3 to 4 passes to avoid the breakage of rice during milling. In actual practice, the two methods that are commonly used are sun drying and mechanical drying.

3 CONVENTIONAL METIIOD

3.1 The conventional parboiling of paddy at domestic level is done either in earthen pitchers and/or in metallic containers of varying sizes from 10 kg to 500 kg. However, at commercial level, there is a well-defined process and the rice millers follow either single boiling method or double boiling method. The conventional parboiling process has some drawbacks of imparting off-flavour and development of myco-toxins in the rice because of fermentation due to prolonged soaking in cold water, being labour and weather dependent and requiring a large land area for drying.

3.1.1 *Single Boiling*

Cleaned raw paddy is soaked in water at room temperature for 24 hours to 72 hours in the tank. The water is then drained and the soaked paddy is transferred into cylindrical iron kettles for steaming. The kettles are normally two or three in numbers each approximately holding 350 kg to 750 kg of paddy. The soaked paddy is steamed for 3 minutes to 8 minutes or till the steam comes out of the top and bottom of the kettle. Steamed paddy is then taken to the open drying yard for drying in the sun.

3.1.2 *Double Boiling*

This method is a further improvement over single boiling. In this method, the raw paddy is first steamed in the steaming kettle to raise the temperature of paddy. The steamed paddy is then soaked in cold water in the soaking tank for 24 hours to 48 hours and then the water is drained off. The soaked paddy is then steamed second time in the kettle to complete the parboiling process. This method seems to offer the advantage of making the grain sterile so that during soaking there is less organic fermentation of the paddy/and of the impurities mixed with it. In addition, hot dry paddy poured into the water raises its temperature and facilitates soaking, which is thus concluded in a shorter time.

4. MODERN METHODS OF PARBOILING

4.0 Besides utilizing conventional methods of single boiling (*see* **3.1.1**) and double boiling paddy (*see* **3.1.2**), a number of improved practices have been developed and are being adopted. Though modern methods of parboiling may appear to be more expensive as compared to conventional methods due to high initial investment and higher operational cost, the increased capacity due to shorter parboiling

time resulting in increased rice justifies installation of modern plants.

4.1 CFTRI Hot-Soaking Method

In this method, the parboiling tanks are filled with clean water and heated to a temperature of about 85 °C to 90 °C by passing steam through the coils inside the tank. Sometime, hot water is prepared in a separate hot water tank before it is pumped into the parboiling tank. This process saves time and increases the capacity. The paddy is dumped into the hot water as quickly as possible. By a mechanical system, the paddy is lifted by an elevator and dumped into the parboiling tanks for soaking. The resulting temperature of the paddy water mixture in the tanks stays at about 70 °C to 75 °C. The soak water can be recirculated into the hot water tanks to maintain a constant temperature of 70 °C. After letting the paddy soak for 3 hours to 4 hours, the soak water is drained and the water discharge valve is left open to remove water. During steaming soaked paddy is exposed to steam heat by letting steam at a pressure of about 400 kPa (4 kgf/cm^2) through the open steam coil. Splitting of husks usually indicates completion of the parboiling process. After steaming is complete, the paddy is removed for drying. If a mechanical dryer is to be used, the parboiled paddy is conveyed to the dryer by a conveyor. If the parboiled paddy is to be sun dried, it is transported to the drying yard. Mechanical drying is preferable to sun drying because it saves space and minimizes the cost of parboiling apart from uniform drying resulting less brokens.

4.1.1 Before the paddy is fed into the parboiling unit, it is desirable to remove chaff, dirt and other impurities by passing the paddy through a cleaner. Greater cleanliness can be achieved by washing the paddy in a separate tank before it is dumped into the parboiling tanks. In this operation, even light chaff and heavy stones can be separated from paddy.

4.1.2 For parboiling, the water requirement is about 1.25 times the mass of paddy to be parboiled and the requirement for steam is about 200 kg/t of paddy.

4.1.3 Suggested equipment for parboiling plants with capacities of 12, 24, 48, 96 and 120 t/day are given in Table 1.

4.2 Pressure Parboiling Method

The principle of this method is the penetration of moisture into the paddy in the form of water vapor under pressure which gelatinizes the starch in the kernels.

4.2.1 The paddy is soaked in warm water (85 °C to 90 °C) or cold water for 30 minutes to 60 minutes. Water is then drained out. The steam is passed to raise the pressure gradually between 100 kPa to 200 kPa (1 kgf/cm^2 to 2 kgf/cm^2). After steaming for 20 minutes to 30 minutes, steam is blown out. The air entrapped inside the rice kernel is driven out by the penetration of water vapor, therefore, the presence of bellies in the parboiled rice is avoided. The rice obtained by this method has pleasing, slightly yellowish and uniform colour. The main advantages of this method are reduction in soaking time, reduction in drying time and cost, and increase in shelling efficiency (nearly 80 percent of the paddy husk splits during steaming) and increase in milling outturn because the grains are resistant to breakage. Increase in the fat content in the bran and in the storage life of bran has also been observed. In this method, the parboiling tanks must be completely closed and made of thick metal sheets to withstand pressure.

4.2.2 The process should be easy to convert to a continuous one and have the potential to be introduced even in small size mills as a replacement for the conventional parboiling system.

4.2.3 For parboiling the paddy for the purpose of making rice, clean paddy is fed into the parboiling tanks filled with cold water which is recirculated for some time and then it is drained out. Steam is let into the tanks. The tanks have a welded top cover and hence work as a pressure vessel during steaming. This hastens the parboiling process and the requirements of water and steaming are reduced.

4.3 Dry Heat Parboiling Method

The paddy is soaked in hot water at 70 °C to 80 °C and left over night, Water is drained out in the morning. The soaked paddy is now passed through a grain roaster in which sand paddy mix temperature is maintained at 140 °C to 160°C by an oil/busk fired furnace. During travel of the soaked paddy for 60 seconds to 80 seconds in the grain roister the paddy is parboiled. The parboiled paddy having a moisture content of about 20 percent is dried in a mechanical dryer having a capacity about 300 kg to 800 kg paddy per hour or in the sun.

5 SEQUENCE OF OPERATION

To maximize the use of a processing plant and its machinery, a process analysis of all the unit operations is to be used to determine the sequence of various operations and the utilization efficiency of the handling equipment. Various unit operations of

a parboiling process are given in Table 2.

6 EQUIPMENT AND STRUCTURE

Suggested list of equipment and structures for a modern 4 t/h parboiling plant is given in Table 3.

Table 1 Equipment Required for Parboiling Plants of Different Capacities
(*Clause* 4.1.3)

Sl No.	Equipment	Capacity of Parboiling Plant (t/day)				
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	Receiving bin					
	a) Number	1	1	1	1	1
	b) Capacity, t	15	30	60	120	150
ii)	Receiving elevator					
	a) Number	1	1	1	1	1
	b) Capacity, t/h	12	20	25	25	30
iii)	Holding bin					
	a) Number	—	—	1	1	1
	b) Capacity, t	—	—	6	8	10
iv)	Parboiling tank Elevator					
	a) Number	—	—	1	1	1
	b) Capacity, t/h	—	—	20	20	25
v)	Parboiling tank					
	a) Number	1	2	4	6	8
	b) Capacity, t	7.5	7.5	7.5	7.5	7.5
vi)	Belt conveyor					
	a) Number	—	—	1	1	1
	b) Capacity, t/h	—	—	24	32	40
vii)	Drier					
	a) Number	1	1	2	4	6
	b) Holding capacity†, t	6	12	12	12	12
viii)	Elevator capacity, t/h	12	24	24	24	24
ix)	Tempering bin					
	a) Number	2	2	3	4	6
	b) Capacity, t	6	12	12	12	12
x)	Boiler capacity, kg/h	300	600	1 200	1 600	2 400

† Parboiling tanks are 25 percent larger than the tonnage capacity to allow for swelling during soaking. Holding capacity of driers should be tonnage capacity (raw paddy) to hold parboiled rice.

Table 2 Details of Unit Operations in Parboiling and Drying Process
(*Clause* 5)

Sl No.	Operation	Time Required	Remarks
(1)	(2)	(3)	(4)
i)	Cleaning of raw paddy to remove dirt, dust, stones, chaff and other impurities	—	Time of operation depends upon the amount of foreign matter present
ii)	Soaking of clean paddy in hot water keeping the temperature of the paddy-water mixture (constantly at 70°C) recirculate water if required to maintain temperature	3 h to 5 h	-
iii)	Steaming the soaked paddy, after draining the soaking water, by injecting saturated steam at pressure of 400 kPa (4 kgf/cm^2)	20 min to 40 min	Time for steaming depend on quality of paddy to be steamed and capacity of boiler
iv)	First drying pass, paddy is recirculated in dryer and 95 °C air is blown through the paddy	3 h	—
v)	Tempering of paddy in tempering bin to equalize mixture	8 h	—
vi)	Second drying pass, paddy is recirculated in dryer and 75 °C air is blown through the paddy	1 h	—

Table 3 Equipment and Structures for a Modern 4 t/h Parboiling Plant
(*Clause* 6)

Sl No.	Item/Equipment	Size	Quantity
(1)	(2)	(3)	(4)
i)	Receiving elevator	25 t/h	1
ii)	Receiving bin hopper bottom	120 t	1
iii)	Scalper-pre-cleaner	6 t/h	1
iv)	Elevator for parboiling tank	24 t/h	1
v)	Holding bin hopper bottom	8 t	1
vi)	Parboiling tanks	6 t	4
vii)	Belt conveyor	32 t/h	1
viii)	Bucket elevator for dryer/ tempering bin	32 t/h	2
ix)	Hot water tank	5 000 litres	2
x)	Hot water pump	28 litres/s	1
xi)	Mechanical dryers (oil/husk fired)	12 t/h	2
xii)	Tempering bin	12 t	2
xiii)	Boiler (husk fired) with accessories and steam pipes as required	1 600 kg steam/h	1
xiv)	Tube wells	—	1
xv)	Overhead reservoir	—	1
xvi)	Foundation and civil works	—	—
xvii)	Pipe works for steam and water	—	—
xviii)	Electrical works	—	—
xix)	Steel structure with platform and roof for the plant	1 600 t	—
xx)	Godown	—	—
xxi)	Office	—	—
xxii)	Boiler house	—	—

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